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C.H. HUCKELBERRY
County Administrator

June 2, 2016

Mr. David Castanon, Chief, Regulatory Division
U. S. Army Corps of Engineers, Los Angeles District
915 Wilshire Boulevard
Los Angeles, CA 90017

Re: **Environmental Impact of the Rosemont Mine on Davidson Canyon and Cienega Creek**

Dear Mr. Castanon:

As we near the end of the federal review process for the proposed Rosemont Mine, there are many key uncertainties that Pima County believes need to be addressed in order to comply with the letter and the spirit of the National Environmental Policy Act (NEPA). Disclosing how the mine will affect Davidson Canyon and Cienega Creek, two areas recognized as Outstanding Waters by State of Arizona, is central to public accountability under this federal law. County staff have repeatedly pointed out woeful inadequacies in the Forest Service's statement of environmental impacts to these streams.

In December 2015, County staff produced another report that used the best available data to model the predicted mine impacts on water resources in Davidson Canyon. In response, Rosemont contractors attempted a wide-ranging critique of the County's work. The contractors focused on the perceived limitations of the data and statistical methods used. The attached report includes a rebuttal to the critique made by Rosemont contractors and addresses the primary concerns raised in their April 2016 report.

The Rosemont contractors are long on criticism but short on answers. Once again, Rosemont failed to use their own data or new analyses to assist the federal and state decision-making processes. For example, although Water and Earth Technologies Inc. (co-authors on the Rosemont Contractors' report) installed precipitation and stream gauges in the Barrel Canyon watershed at some point the past, none of these data were presented in their April 2016 report to address the purported lack of rainfall data.

The Rosemont Contractors' report presents itself as being an expert treatise in statistical methods and tests and stream gage methodologies, but the 'experts' who wrote this report are anonymous. The reader is left with the inability to understand and evaluate the qualifications behind those attempting to discredit the conclusions that statistically sound modeling efforts using the best available data yield. In contrast, County staff placed their names front and center on the December 2015 report.

The fundamental facts remain: Pima County's data highlight the deficiencies of the federal analysis regarding the effects of reductions in storm water flow and baseflows will have on Davidson Canyon, reductions which are in part due to dredge and fill activities under the Corps' jurisdiction. The best available data show that reducing the water inputs to Davidson Canyon will significantly reduce runoff, recharge, as well as surface flow extent which will negatively impact riparian and aquatic life in Davidson Canyon and Cienega Creek.

Sincerely,

C. Huckelberry

C.H. Huckelberry
County Administrator

CHH/anc

Enclosures

c: The Honorable Chair and Members, Pima County Board of Supervisors
Sallie Diebolt, U.S. Army Corps of Engineers
Mindy Vogel, Coronado National Forest
Rob Leidy, U.S. Environmental Protection Agency
Ted Boling, Council on Environmental Quality

HUDBAY

April 19, 2016

Rob Leidy, PhD
U.S. Environmental Protection Agency
Wetlands Office (WTR-2-4)
75 Hawthorne Street
San Francisco, CA 94105

Re: Pima County Letter Dated December 17, 2015

Dear Dr. Leidy:

Through a public records request to Pima County, Rosemont Copper Company (Rosemont) received a copy of a letter dated December 17, 2015 that was addressed to you. This letter from Chuck Huckelberry the County Administrator of Pima County, entitled "*Rosemont Mine – Surface Water Impacts, Davidson Canyon and Cienega Creek,*" transmitted a memorandum from Pima County's Sustainability and Conservation staff that we found troubling for a number of reasons. As such, Rosemont believed that clarification was required. Attached you will find our consultants' analysis of the information provided by Pima County.

In short, we found the memorandum skewed data, overstated impacts and called into question scientific analysis performed over several years without any basis. While we are sure your own review found many of these same points, Rosemont believed that it was important to provide a clear analysis in the record. We therefore are copying this document to Pima County and to all other agencies we believe had received it. If I have missed anyone in our cc listing below that you are aware of, I would appreciate if you would forward our analysis to those agencies.

If you have any questions, or would like to discuss the attached document in greater detail, please contact me.

Regards,

Katherine Ann Arnold

Katherine Ann Arnold, PE
Director, Environment

Attachment: *Response to Powell et al (2015), "New Analysis of Stormflow and Groundwater Data from Davidson Canyon: Evidence for Influence of Stormwater Recharge of Groundwater*

cc: Ms. Sallie Diebolt, Corps of Engineers

Ms. Mindy Vogel, Forest Service
Ms. Linda Taunt, Arizona Department of Environmental Quality
Mr. Chuck Huckelberry, Pima County
Ms. Suzanne Shields, Pima County
Ms. Linda Mayro, Pima County
Mr. Chris Garrett, SWCA

Doc. No. 026/16-15.4

RESPONSE TO POWELL ET AL. (2015), "NEW ANALYSIS OF STORMFLOW AND GROUNDWATER DATA FROM DAVIDSON CANYON: EVIDENCE FOR INFLUENCE OF STORMWATER RECHARGE OF GROUNDWATER"

Prepared for:

Rosemont Copper Company
5255 East Williams Circle, Suite W1065 ● Tucson, Arizona 85711

Project Number: 1049.91
April 19, 2016

Prepared by:

WestLand Resources

Water & Earth Technologies
Water Resources and Environmental Consulting

NEIRBO HYDROGEOLOGY

TABLE OF CONTENTS

TABLES

FIGURES

1. INTRODUCTION

Via a letter dated December 17, 2015, Pima County Administrator Chuck Huckleberry transmitted to the U.S. Environmental Protection Agency (EPA) a memorandum by Powell et al. (2015) providing analyses of recent flow and well data from Barrel and Davidson canyons. This memorandum, in conjunction with another memorandum developed by Pima County staff (Powell et al. 2014), purportedly demonstrate that the "impacts of the proposed Rosemont mine on stormwater and baseflows to Davidson Canyon have been understated in both the final environmental impact statement [prepared by the U.S. Forest Service (USFS 2013)] and the draft water quality certification by the Arizona Department of Water Quality [ADEQ; (ADEQ 2014a)]."

Powell et al. (2015) provide three general conclusions related to hydrology in Davidson Canyon:

1) Barrel Canyon provides a disproportional amount of surface water within the Davidson Canyon watershed.
2) The shallow groundwater aquifer in Davidson Canyon is highly responsive to pulses of surface water flow.
3) Additional analysis of the relationship between depth to water and length of streamflow in Davidson Canyon reaffirms an earlier analysis by Powell et al. (2014) for a strong statistical relationship between these two variables.

However, as with the previous memorandum (Powell et al. 2014), Powell et al. (2015) include errors in analysis and interpretation that undermine these conclusions. In this report, we respond to the above three assertions by Powell et al. (2015), and demonstrate the following:

1) The comparison of surface water runoff in Barrel Canyon to that in lower Davidson Canyon is based on a flawed application of the surface water gauge data in both systems. In addition, the dataset is so limited that it renders the analysis nearly meaningless.
2) The relationship between stormwater runoff and the recharge of the shallow alluvial aquifer is well understood by the permitting agencies. The "demonstration" of the runoff-recharge relationship by Powell et al. (2015) neither refutes nor adds to the disclosure of effects in the Forest Service Final Environmental Impact Statement (FEIS; USFS 2013), or the decision by ADEQ to issue the CWA Section 401 water quality certification (ADEQ 2014a).
3) The statistical analysis is based on substantial flaws in both the methodology used and the interpretation of results, resulting in inappropriate conclusions about the relationship between depth to water and length of streamflow.

We address each of the conclusions, and the associated flaws with each, in the subsequent sections.

2. CONTRIBUTION OF BARREL CANYON TO DAVIDSON CANYON

Powell et al. (2015) assert that Barrel Canyon contributes a "disproportional" share of the surface water volume measured at a gauge within Davidson Canyon. The authors compared storm flow data measured at two gauge stations: Davidson Canyon Automated Local Evaluation in Real Time (ALERT) Gauge 4310 (data point ID 4313) and the Barrel Canyon U.S. Geological Survey (USGS) Gauge (#94845680). The Davidson Canyon ALERT gauge is located approximately 0.2 mile south (upgradient) of the U.S. Interstate 10 (I-10) crossing of Davidson Canyon. The Barrel Canyon USGS gauge is located over 12.5 miles upgradient of the Davidson Canyon ALERT gauge, as shown in Figure 1 of Powell et al. (2015).

Powell et al. (2015) assert that while Barrel Canyon comprises only 28 percent of the total watershed area reporting to the Davidson Canyon ALERT gauge, measured storm flow at the Barrel Canyon USGS gauge indicate that Barrel Canyon contributes 39 percent of the total storm flows reporting to the Davidson Canyon ALERT gauge. They summed the total volume of "stormwater" recorded from July 15 through November 25, 2015 at the Davidson Canyon ALERT gauge (470 acre-feet) and compared it to the total volume of water measured at the Barrel Canyon USGS gauge over the same period (186 acre-feet). However, the conclusions by Powell et al. (2015) are based on an inadequate and oversimplified review of the flow data at the respective gauges. First, it is inappropriate to use ALERT data, which is collected for flood detection and early warning purposes, to calculate flow volumes. The flow volumes calculated from the Davidson Canyon ALERT gauge data are grossly underestimated in Powell et al. (2015). If the flow volume from Barrel Canyon were compared to a more realistic estimate of the flow volume at Davidson Canyon, the "disproportionately large" contribution from Barrel Canyon would no longer be apparent. **Section 2.1** addresses this issue in more detail.

Powell et al. (2015) entirely overlooks the spatial and temporal variation of rainfall in drawing conclusions about its relationship with surface water volumes at different locations within the 32,320-acre watershed. An analysis of rainfall data that illustrates this oversimplification in Powell et al. (2015) is included in **Section 2.2**.

Furthermore, Powell et al. (2015) does not consider spatial variability and assumes that all storm flow reporting to the Barrel Canyon USGS gauge would ultimately contribute to flow volumes measured at the Davidson Canyon ALERT gauge, despite the fact that over 12.5 miles of stream channel and alluvial sediments separate the two gauges. In reality, infiltration can exceed runoff volumes causing transmission losses that can result in alternating flowing and dry stream reaches. This response is typical of ephemeral channels in arid regions. The runoff contributions from other sub-watersheds that could contribute to flow volumes at the ALERT gauge was also ignored in Powell et al (2015). The comparison of summed stream flow volumes at two locations far apart in the watershed is a serious oversimplification of the stream system. **Section 2.3** discusses this in more detail.

2.1. Use of ALERT Gauge Discharge Data for Hydrologic Analysis

Powell et al. (2015), analyzed discharge data from the ALERT Gauge located in Davidson Canyon (Station 4310, operated by the Pima County Regional Flood Control District with discharge data designated with ID 4313). These data were used to calculate the total volume of runoff for Davidson Canyon for comparison with values from the USGS stream gauge in Barrel Canyon. The USGS collects hydrometeorological data for the purpose of quantifying water resources, and their monitoring methods have been developed to provide the most accurate estimates of streamflow over the most commonly encountered flow conditions, which are low flows and the moderate flows that occur frequently. The USGS gauge objectives include accurate estimates of discharge through the full range of stages. This methodology is imperative for flow data used to support hydrologic studies or to estimate flow volume.

ALERT gauges are used for early flood detection and are not typically designed to provide accurate measurement of low and moderate flows. Like water resources entities, flood detection entities measure stage, not flow rate directly. Stream stage (also called stage or gauge height) is the height of the water surface, in feet, above an established elevation where the stage is zero. The zero level is arbitrary, but is often close to the streambed. From measurements of stage, flow rate (discharge) is calculated using a stage-discharge relationship. The stage-discharge relationship is unique to each gauge site as a result of variations in the channel shape and slope that impact how the velocity of the flow varies with its stage. Stage-discharge relationships change over time, and water resources entities must frequently employ rating adjustments (rating shifts) to account for changes in sensor installation or changes in channel bed elevation or shape due to aggradation or degradation, stream bank erosion or even changes to vegetation in the channel that impact flow efficiency at their gauges. Rating adjustments are very common as quality control measures.

Powell et al. (2015) present no discussion of the stage-discharge relationship used at the ALERT gauge to estimate discharges in Davidson Canyon. The calculation of the total volume of runoff is very dependent on the accuracy of the method and stage-discharge relationship used to estimate discharges for all measured flow events. We investigated the stage-discharge relationship by reviewing streamflow data for the Pima County ALERT Gauge 4310, including stage (point ID 4313) and discharge time series (Pima County Precipitation and Streamflow Data, http://alert.rfcd.pima.gov/perl/pima.pl). The period of record for the data is 3/3/2007 to the present. No large gaps in data were noted but the data are irregularly-spaced in time, which is expected for an ALERT gauge that is designed to transmit data primarily during flood events.

The entire stage and discharge dataset was sorted by stage and duplicate data entries were removed. The resulting dataset describes the stage-discharge relationship at the gauge (**Table 1**), which is used to calculate discharge in cubic feet per second (cfs) from measured stage data transmitted in feet from the gauge.

Table 1. Stage-discharge tabular relationship developed from stage, discharge time series data for gauge ID 4310

Stage (feet)	Discharge (cfs)	Stage (feet)	Discharge (cfs)
-0.1	0	1.9	1120.67
0.0	0	2	1210
0.1	0	2.1	1315
0.2	0	2.2	1420
0.3	0	2.3	1525
0.4	0	2.4	1630
0.5	0	2.5	1735
0.6	0	2.6	1840
0.7	0	2.7	1945
0.8	0	2.8	2050
0.9	0	2.9	2155
1.0	0	3	2260
1.1	0	3.1	2379
1.2	0	3.2	2498
1.3	0	3.3	2617
1.4	674	3.5	2855
1.5	763.33	3.6	2974
1.6	852.67	3.8	3212
1.7	942	4	3450
1.8	1031.33		

Based on the review of the ALERT stage and discharge data, the minimum stage where discharge is estimated is 1.4 feet, with a corresponding discharge of 674 cfs. As an ALERT gauge installed to provide flood early warning as its primary intent, Davidson Canyon ALERT gauge *only defines flow when the stage exceeds 1.4 feet above the channel.*

All measured stage values below 1.4 feet correspond to a reported flow of 0 cfs. The ALERT gauge data indicate that runoff conditions measured at this gauge with flows between 0 and 674 cfs are not being reported. The stage and discharge data for 7/15 - 11/25/2015 are presented in **Figure 1**. The stage at 1.4 feet where non-zero discharge is reported (stage threshold) is also shown. Small stage values (e.g., < 0.5 feet) and variations (e.g., +/- 0.1 foot) shown in the stage data presented in **Figure 1** likely represent common sensor measurement errors that can be caused by extreme heat or long periods of dry conditions.

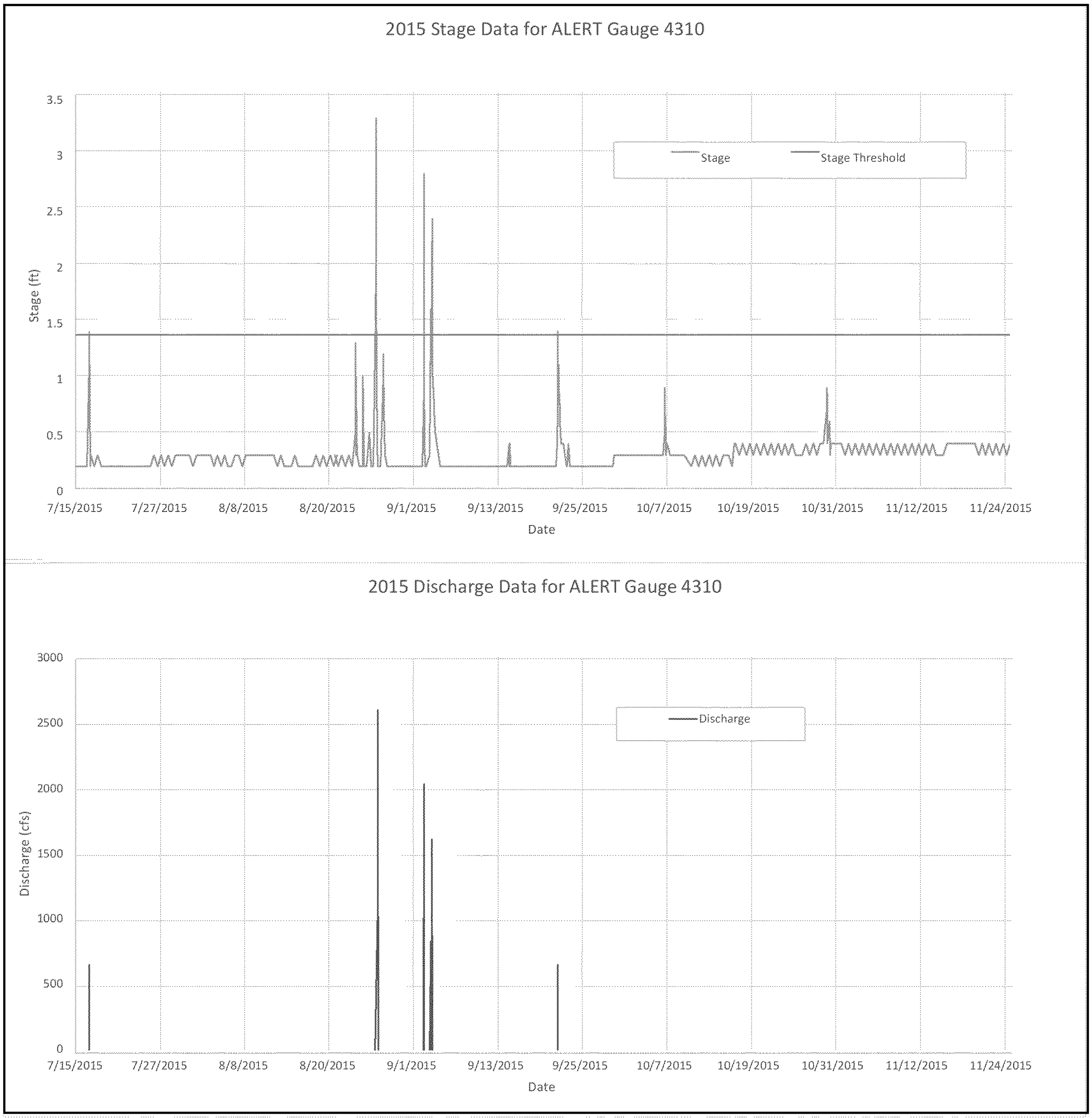

Figure 1. Stage and Discharge Data for ALERT Gauge 4310, 7/15 – 11/25/2015

Investigation into the measured stages during 7/15 – 11/25/2015 show that non-zero estimates of discharge were reported for only five (5) runoff hydrographs (shown in green in **Figure 1**) in that period. There were an additional six (6) events with measured stages greater than or equal to 0.5 feet but less than 1.4 feet during 2015 (shown in blue in **Figure 1**). For these six events, discharges of zero (0) cfs were provided in the ALERT data record.

All flows from 7/15 – 11/25/2015 with measured stages less than 1.4 feet were unaccounted. This includes three (3) events between 1.0 foot and 1.3 feet. Discharge during these smaller events is significant, considering that the rated discharge for a stage of 1.4 feet is 674 cfs. The cumulative volume of runoff from hydrographs with stage magnitudes less than 1.4 feet were not included in the runoff volume computations presented in Powell et al. (2015). The total volume calculated does not account for all runoff at the gauge, and underestimates the actual runoff volumes during the 2015 analysis period. Therefore, Powell et al. (2015) is overestimating the flow contribution from Barrel Canyon. The true runoff contribution of Barrel Canyon as a fraction of Davidson Canyon runoff for these specific flow events cannot be determined with the data available.

In comparison, the USGS gauge data (Gauge 09484580 Barrel Canyon near Sonoita, AZ) presented in Powell et al. (2015) quantifies discharge for runoff events ranging from 0.02 cfs to 1,780 cfs (during the period of record of the data 1/23/2009 to the present). Flow volumes for the Barrel Canyon gauge are more representative of the true volumes since the full range of flows were measured. Volume comparisons in Powell et al. (2015) are inaccurate because the authors compare volumes that were not computed using the same criteria for calculation.

Analysis of the stage and discharge data from 3/3/2007 to the present also shows that the stage threshold at the Davidson Canyon ALERT gauge (stage of 1.4 feet equating to 674 cfs) has not changed over time. Based on the available data, there is no evidence that the rating has been adjusted since gauge installation on 3/3/2007. This indicates that data collection at the gauge is typical for a flood detection gauge, and maintaining a high degree of accuracy for discharge measurements is not a priority. If there have been any changes in the channel due to sedimentation or scour, the rating is not accounting for this channel change and is potentially over- or under-predicting discharge, respectively.

2.2. PRECIPITATION VARIABILITY

During the short July 15 through November, 25, 2015 comparison time period only five (5) runoff events at the Davidson Canyon ALERT gauge were measured. A review of data from the Pima County Flood network and the USGS gauge found a high degree of spatial and temporal variability in rainfall and runoff throughout the watershed for the period. A short time period dataset with a high degree of variability cannot be used with confidence to develop general hydrologic relationships and conclusions representative of the Rosemont Copper Project.

The Pima County precipitation data were investigated via the Pima County Precipitation and Streamflow Data, publicly-accessible website http://alert.rfcd.pima.gov/perl/pima.pl. Two ALERT rain gauges within the Davidson Canyon watershed are described in **Table 2**. The gauges are located 7.5 miles apart. Daily measured rainfall totals from the two gauges for the time period July 15 through November 25, 2015 are charted in **Figure 2**. **Figure 2** demonstrates that rainfall was measured on different days and with varying magnitude. As shown in **Table 3**, the Davidson Canyon ALERT gauge measured more total rainfall during this time period and measured rainfall on more days than Empire peak (70 percent more days with rainfall at Davidson as compared to Empire Peak).

In addition, the higher elevation gauge (Empire Peak) measured less precipitation during this time in 2015 (**Table 3** and **Figure 3**). The two ALERT gauges lie within the Davidson Canyon watershed at elevation differences greater than 2,000 feet (**Table 2**). Rainfall totals during July 15 through November 25, 2015 indicate that the lower elevation Davidson Canyon ALERT Gauge 4310 measured almost 3 inches more rainfall (35 percent greater) than the higher elevation Empire Peak gauge 4320 (**Figure 3**). **Figure 3** also demonstrates variability in rainfall totals measured at other station locations near Davidson Canyon watershed. During this very narrow time period the seven (7) other nearby rain gauges also did not show the orographic precipitation effect stated by Powell et al. (2015).

Table 2. Pima County Davidson Watershed ALERT Rain Gauges

Sensor ID	Site Name	Elevation (ft AMSL)	Location
4310	Davidson Canyon	3,480	Davidson Canyon Wash 0.25 miles south of Interstate 10
4320	Empire Mountain	5,590	Empire Peak

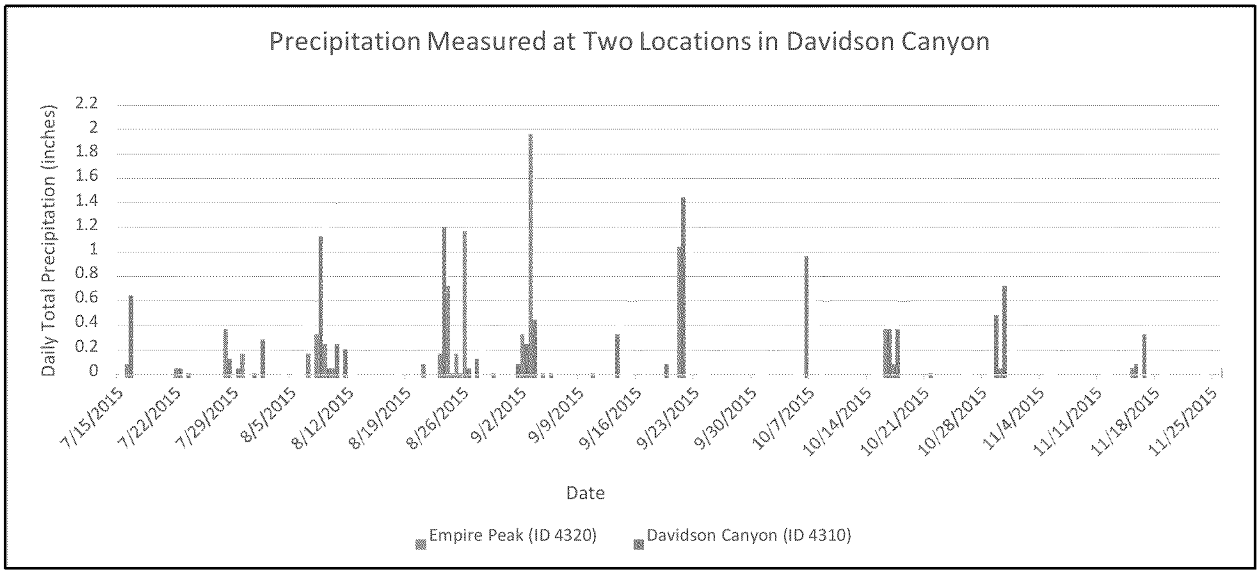

Figure 2. Measured Precipitation

Table 3. Pima County Davidson Watershed Rain Gauges

Sensor ID	Site Name	7/15/2015 – 11/25/2015 Total Measured Rainfall (inches)	7/15/2015 – 11/25/2015 Number of Days with Measured Rainfall
4310	Davidson Canyon	11.3	34
4320	Empire Mountain	8.4	20

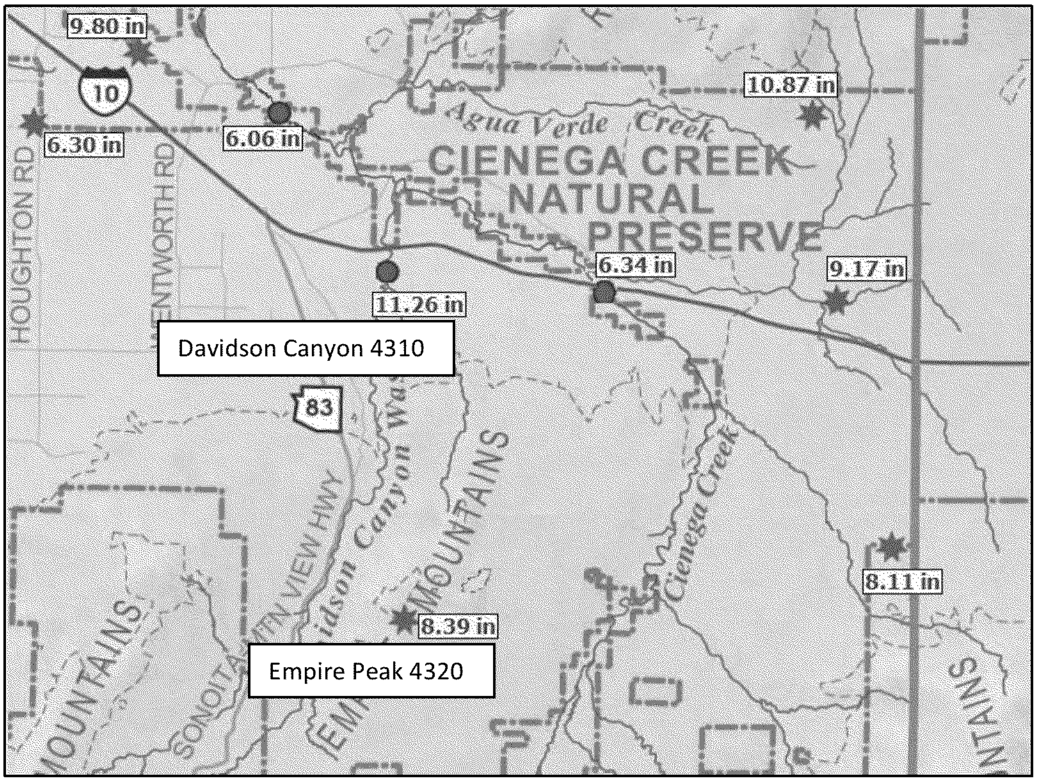

Figure 3. Precipitation measured by several Pima County ALERT rainfall gauges in and near Davidson Canyon. Total measured rainfall during 7/15-11/25/2015

This observation of rainfall variability is particularly ironic given that Powell et al. (2015) contend that, "The EIS discussion does not take into account the higher elevation difference of the Barrel watershed and the increased rainfall and runoff of the watershed, and thus underestimates the flow contribution of the Barrel watershed to Davidson Canyon."

The Forest Service FEIS does, in fact, note this orographic effect, as follows:

> *Cooperating agencies have commented that these estimated reductions in flow to Davidson Canyon may be underestimated because the mine site is located at the head of the watershed at a higher elevation and because due to orographic effects on precipitation, the relative contribution of water to the watershed is greater from these areas. This effect is acknowledged as being likely. However, Barrel Canyon is only one drainage that arises off of the Santa Rita Mountains and supplies Davidson Canyon. McCleary Canyon, Scholefield Canyon, Papago Canyon, and Mulberry Canyon also would experience similar orographic effects and (depending on the alternative) would*

> *still supply water to Davidson Canyon. The east side of Davidson Canyon receives drainage from the Empire Mountains. Although these are not as high in elevation as the Santa Rita Mountains (rising to an approximate elevation of about 5,000 feet above mean sea level rather than 6,000 feet above mean sea level), they would likely still have an orographic effect. While it is acknowledged that Barrel Canyon receives higher precipitation due to its location, it is by no means the only part of the Davidson Canyon watershed that does, and the estimates provided are still valid approximations, albeit with some uncertainty.*

So we have demonstrated here that, while the Forest Service FEIS (USFS 2013) did indeed address the orographic effects on rainfall variability, the short-term dataset shows variability that does not always adhere to the expected relationship.

2.3. RUNOFF VARIABILITY

Powell et al. (2015) presents runoff volumes for the time period July 15 through November 25, 2015 at USGS Gauge (09484580 Barrel Canyon near Sonoita, AZ) near the mouth of the Barrel Canyon tributary and at Pima County ALERT Gauge (ID 4310) approximately 2 miles upstream from the mouth of Davidson Canyon. The USGS gauge is nine (9) (aerial) miles away from the Davidson ALERT gauge, separated by approximately 12.5 miles of stream channel.

Total runoff volumes from July 15 through November 25, 2015 at the two gauges are shown graphically in **Figure 4**, which demonstrates the variability in timing of runoff between the two gauges. There were occurrences of runoff measured at the Barrel gauge on days when no runoff was measured at the Davidson gauge. Conversely, there were days when the Davidson gauge measured runoff when no runoff was measured at the Barrel gauge. There are only three (3) measured runoff events during this time period when runoff was measured at both gauges on the same day.

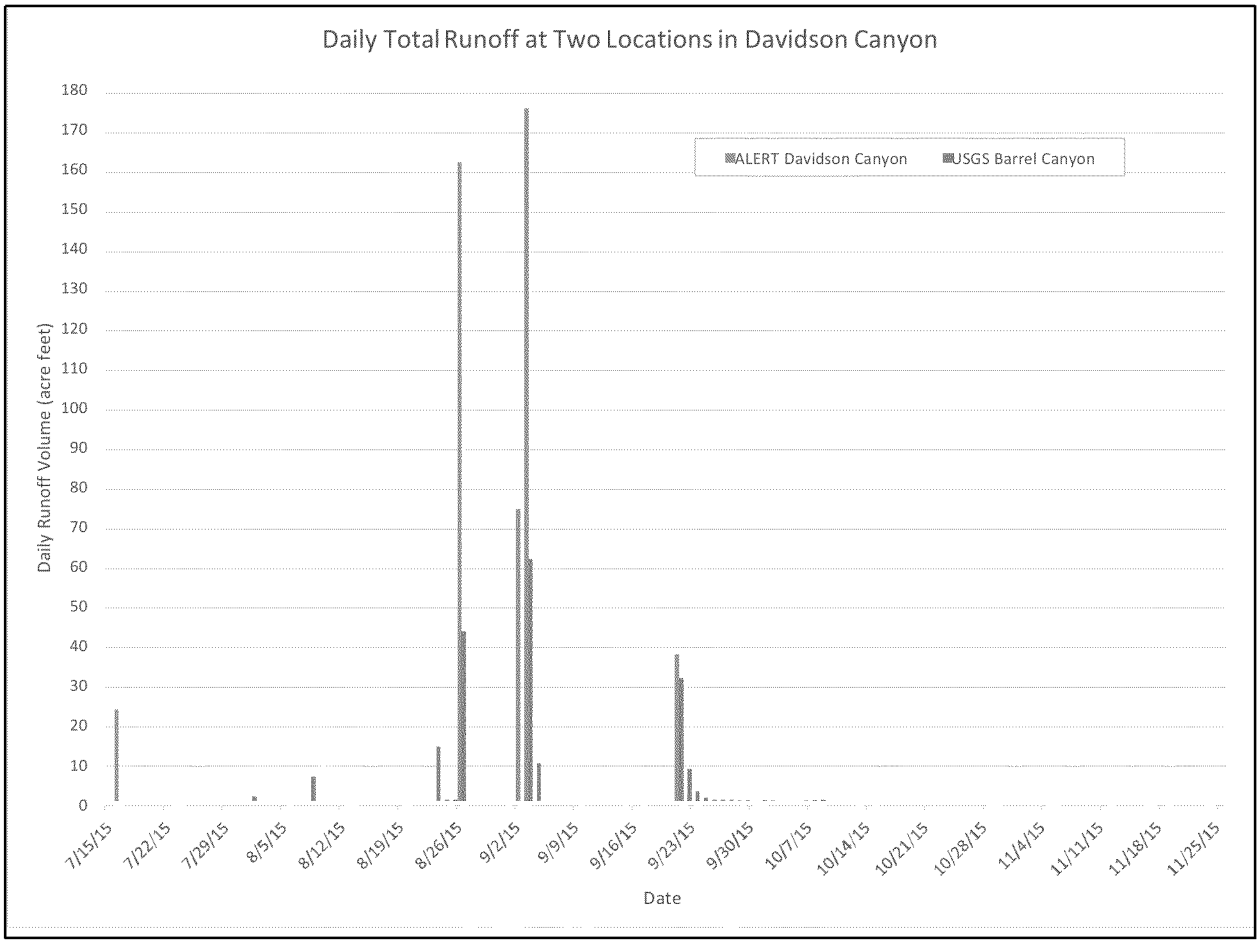

Figure 4. Daily Total Runoff

The number of days with measured runoff for the same time period are shown in **Table 4**. There were more days with measured runoff at the Barrel Canyon gauge as compared to the Davidson Canyon ALERT gauge. This may be due, in part, to runoff with stages less than 1.4 feet not being recorded at the Davidson Canyon ALERT gauge.

Table 4. Days with measured runoff at two locations in Davidson watershed.

Station	Site Name	Number of days with measured runoff 7/15/2015 – 11/25/2015
ALERT 4310	Davidson Canyon	5
USGS 09484580	Barrel Canyon	38 (30 days with flows < 1 cfs)

Runoff volumes measured at different locations in the watershed are expected to vary as a result of variations in timing and depth of rainfall throughout the watershed. Given the variability in rainfall that was observed during the period from July 15 through November 25, 2015, watershed-wide runoff relationships cannot be determined from that short duration dataset.

2.4. Summary of Contribution of Barrel Canyon to Davidson Canyon

Based on the stage and discharge data available on the publicly-accessible website (http://alert.rfcd.pima.gov/perl/pima.pl) for Pima County ALERT Gauge 4310, the discharge data set for the Davidson Canyon ALERT gauge does not adequately quantify discharge through the full range of stages measured at the station. Therefore, computation of runoff volume using these data does not provide accurate volume information and Powell et al. (2015) overestimates the flow contribution from Barrel Canyon. If the flow volume from Barrel Canyon were compared to a more realistic estimate of the flow volume at Davidson Canyon, the "disproportionately large" contribution from Barrel Canyon would no longer be apparent.

The measured rainfall data recorded during the July 15 through November 25, 2015 time period demonstrates variability in rainfall timing and magnitude throughout Davidson Canyon. Measured rainfall at a high elevation location in the watershed shows lower rainfall during July 15 through November 25, 2015 compared to a lower elevation location in the watershed. Daily runoff volumes computed from discharge data at two stations likewise show a high degree of variability as a result of rainfall differences throughout the watershed.

Powell et al. (2015) imply that Barrel Canyon provides a higher proportion of runoff volume to the Davidson Canyon watershed than would be expected, based on contributing area and elevation. Davidson Canyon ALERT gauging station data used for the analysis provide an incomplete discharge computation that cannot be consistently used for comparison to the USGS Barrel Canyon gauge. The analysis was also performed using one short-term dataset containing a high degree of variability in rainfall and runoff. The conclusions presented in Powell et al. (2015) cannot be made based on the data used for the analysis.

3. INFLUENCE OF STREAMFLOW ON AQUIFER RECHARGE IN DAVIDSON CAYNON

A considerable level of effort is made by Powell et al. (2015) to demonstrate a meaningful runoff-recharge relationship evidenced by the storm flow measured at the Davidson Canyon ALERT gauge, and the groundwater levels measured in Davidson #2 Well (Arizona Department of Water Resources [ADWR] Well Registry #808500). The location of the Davidson #2 Well is described by Powell et al. (2015) as being "approximately 150 west" of the Davidson Canyon ALERT gauge. The location is further described by Pima Association of Governments (PAG) (2005) as being "on the west bank of the canyon, approximately 50 feet from the channel." With depth to water measurements in this well ranging between approximately 12 and 27 feet (average 20 feet) (**Figure 5**), the depth of water below the Davidson Canyon channel surface (at the lowest LiDAR-measured elevation of 3446.7 feet amsl) is calculated to range from 0.67 to approximately 16 feet (average 9 feet) (**Figure 6**) (Fonseca et al. 1990, Pima Association of Governments [PAG] 1998, PAG 2013, Powell et al. 2014, Powell et al. 2015).

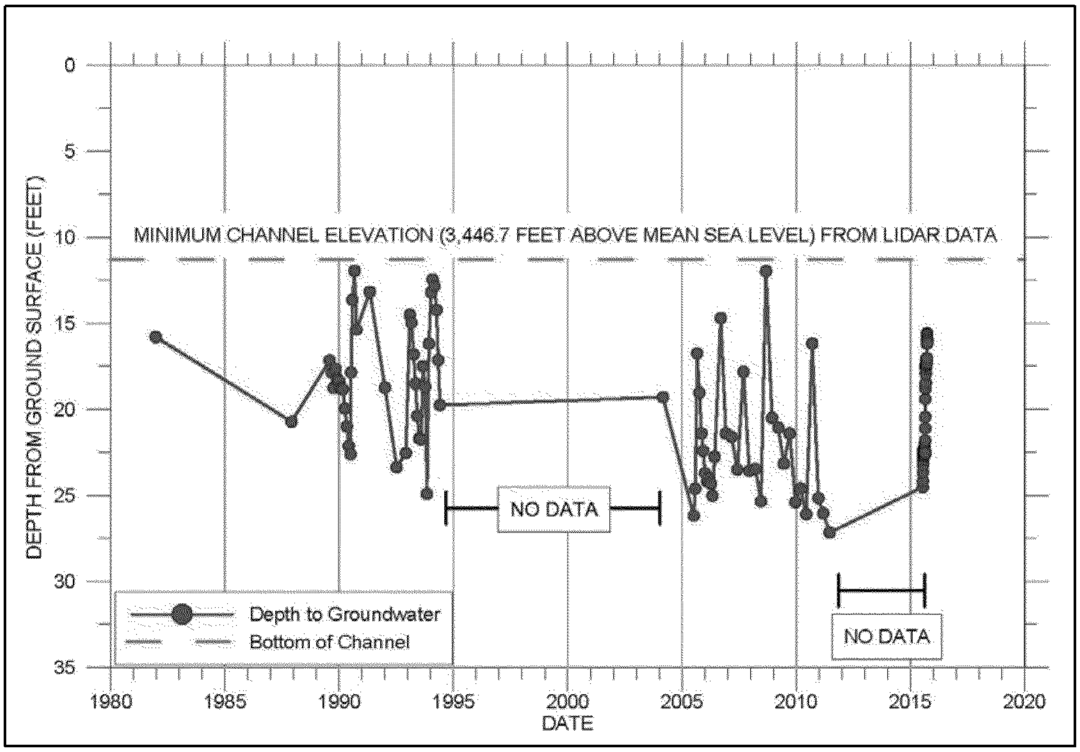

Figure 5. Depth to Groundwater at Well D-16-17 31DCB (Davidson Canyon #2)

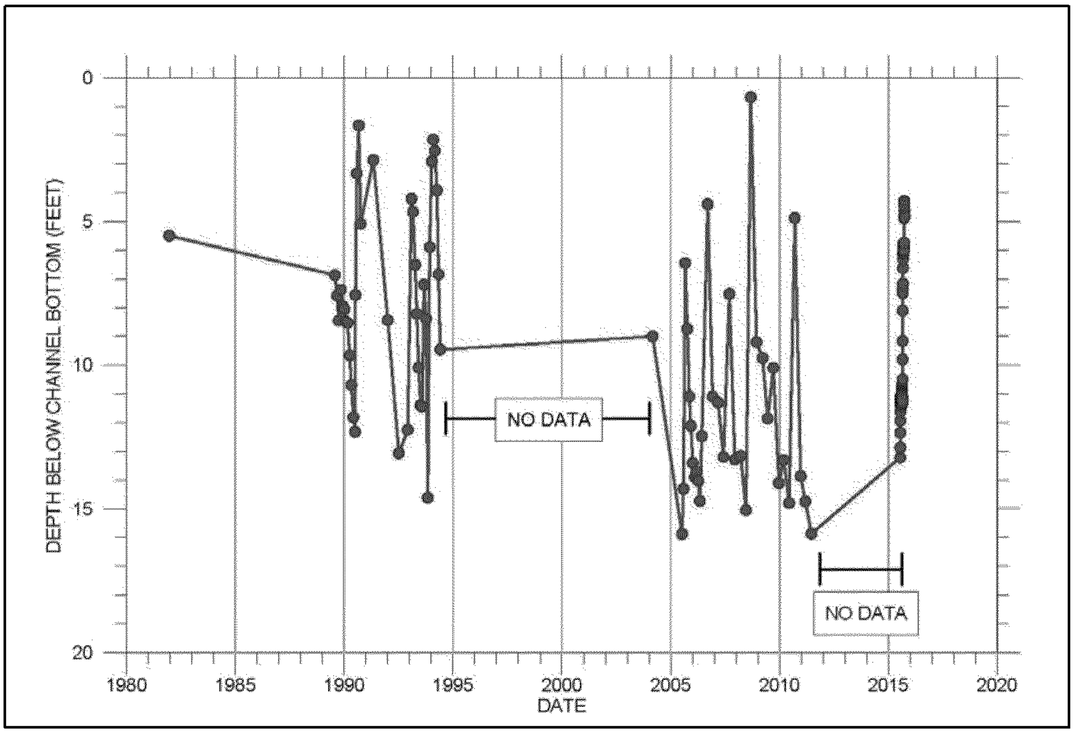

Figure 6. Depth to Groundwater at Well D-16-17 31DCB (Davidson Canyon #2)

Given the location of the Davidson #2 Well in relation to the stream channel, and the fact that the well measures shallow alluvial groundwater, a correlation between stream flow and shallow groundwater level is not only anticipated, it is axiomatic. Indeed, ADWR monitors a series of wells fitted with transducers throughout the state, located adjacent to washes or major river channels, and all of these wells exhibit this same runoff-recharge relationship, e.g. ADWR INDEX well (D-16-16) 14CAC located near Pantano Wash.

Powell et al. (2015) contend that, "...analysis of the impacts of the proposed Rosemont project on Davidson Canyon and Cienega Creek does not take into account [the runoff-recharge] relationship" in Davidson Canyon, supporting their thesis that impacts of the Rosemont Project on Davidson Canyon and Cienega Creek have been "understated" in the Forest Service FEIS (USFS 2013) and the ADEQ 401 water quality certification (ADEQ 2014a). However, this is demonstrably untrue.

The FEIS (p. 536) notes:

> *Changes in surface flow* and, therefore, to the recharge to shallow alluvial aquifers *are possible as a result of disturbance by the mine and the removal of portions of the watershed upstream. The effect of the reduction in surface flow is estimated and could reduce storm flows by 4.3* [for the Preferred Alternative] *to 11.5 percent, depending on alternative, but this effect on recharge is likely to be overestimated, with the contribution being less owing to the distance downstream of the project area and substantial channel losses. Predictions of loss of recharge to the shallow alluvial aquifer have a high level of uncertainty because of the nature of the channels and the relatively great distance between the impacts from the proposed mine and lower Davidson Canyon.* (emphasis added) (USFS 2013)

Similarly, in its "Basis for State 401 Certification Decision" (ADEQ 2014b), ADEQ observes:

> *Reach 2 and Escondido Springs* [in Davidson Canyon] *are strongly influenced by stormwater runoff from summer precipitation which infiltrates the alluvial aquifer (FEIS page 535).* Recognizing the importance of delivering unimpacted stormwater to the downstream watercourses to help recharge the shallow alluvial aquifers*, the Forest Service mitigation measures require that stormwater diversion channels and facility locations be designed and located in order to maintain flow downstream as much as possible and to avoid contact of stormwater with processing facilities and ore stockpiles (FS-SW-O1). The specific stormwater diversions for the Barrel Alternative are also designed to route more stormwater into downstream drainages post-closure (FS-SW-02).* (emphasis added) (ADEQ 2014b)

As shown here, the "demonstration" of the runoff-recharge relationship by Powell et al. (2015) neither refutes nor adds to the disclosure of effects in the Forest Service FEIS (USFS 2013) or the decision by ADEQ to issue the CWA Section 401 water quality certification (ADEQ 2014a).

4. RELATIONSHIP BETWEEN DEPTH TO WATER AND LENGTH OF STREAMFLOW IN DAVIDSON CANYON

Powell et al. (2015) attempt to establish a relationship between *flow length* in Davidson Canyon and *depth to water* at the Davidson #2 well using simple linear regression and multivariate linear regression. In this section, we will show that Powell et al. (2015) misapplies statistical models and misinterprets the results of the statistical models.

In a previous report, Powell et al. (2014) tried to establish a relationship between *flow length* and *depth to water* for Davidson Canyon and Cienega Creek. WestLand (2015) provides a critique of the analysis in Powell et al. (2014). WestLand (2015) did not address the Davidson Canyon model, except to note that because Davidson Canyon is dry most summers (*flow length* = zero), the model could be ignored. Because Powell et al. (2015) refer to the Powell et al. (2014) Davidson Canyon analysis, and uses the same analysis with two or three new data points, we will examine the analyses from both reports.

In general, Powell et al. (2015) and Powell et al. (2014) present conflicting data, misapply statistical models, misinterpret the results of the models, and exaggerate the meaning of the models results. In spite of the myriad errors, there are two in particular that refute their findings:

1) Powell et al. (2014) and Powell et al. (2015) use linear models for sample data with a censored response variable. A censored response variable is a variable that has a physical minimum or maximum limit and sample data at the limit. In this case, *flow length* cannot be less than zero, and there are nine sample points with *flow length* equal to zero.
2) Powell et al. (2014) and Powell et al. (2015) fail to note or understand the effect of *seasonal changes* on the regression model. The variable *month* (March, June, September, and December) explains almost as much of the variation in *flow length* as *depth to water*; therefore, another interpretation is that both *depth to water* and *flow length* are responding to seasonal changes (e.g. precipitation).

The remainder of the section is divided into four subsections; the first two cover the two main statistical errors, the third subsection discusses some of the other statistical errors found in Powell et al. (2015), and the final is a summary of the section.

4.1. Powell et al. (2014) and Powell et al. (2015) Use Linear Regression to Model Sample Data with a Censored Response Variable

Figure 7 shows the data from Figure 5 of Powell et al. (2014). There are twenty-six data points, with eight from June plotted in red, and one from an unknown date plotted as a green square. The *flow length* is zero for nine of the sample points. For the nine sample points with zero *flow length*, the Powell et al. (2014) depth to water ranges from 20.2 feet to 29.5 feet, with a range of 9.3 feet. The range of *depths to water* for all sample points is 17.5 feet (12.0 to 29.5 feet). The range of *depth to water* for sample points with zero *flow length* covers over half the total range for the sample.

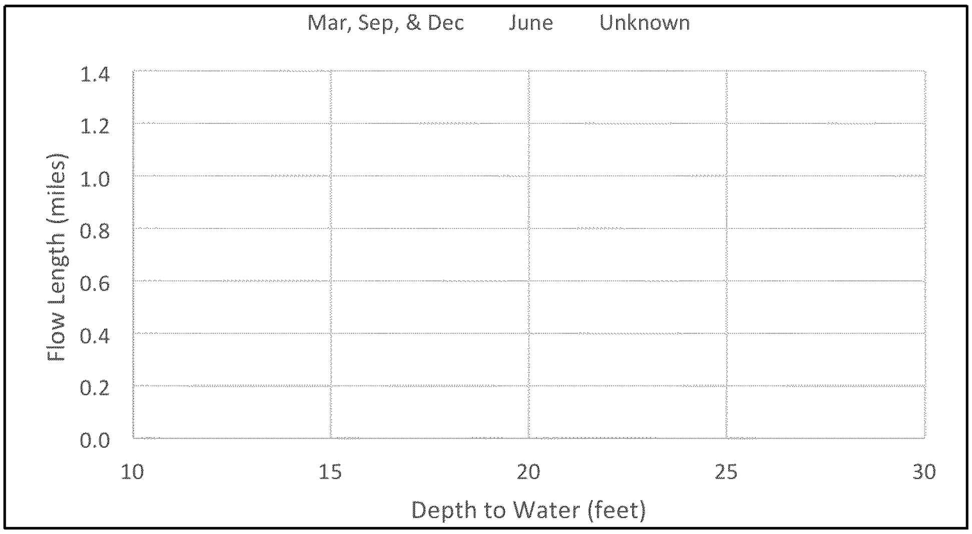

Figure 7. Davidson Canyon *flow length* versus *depth to water* at well Davidson #2. Data from Figure 5 of Powell et al. (2014).

Figure 8 shows the data from Figure 6 of Powell et al. (2015). The points in **Figure 8** are the same as **Figure 7** except that two points (plotted in red) have been added[1]. The data in **Figure 8** still include nine sample points with flow length equal to zero, and cannot be modeled using linear regression as was done in both Powell et al. (2014) and Powell et al. (2015).

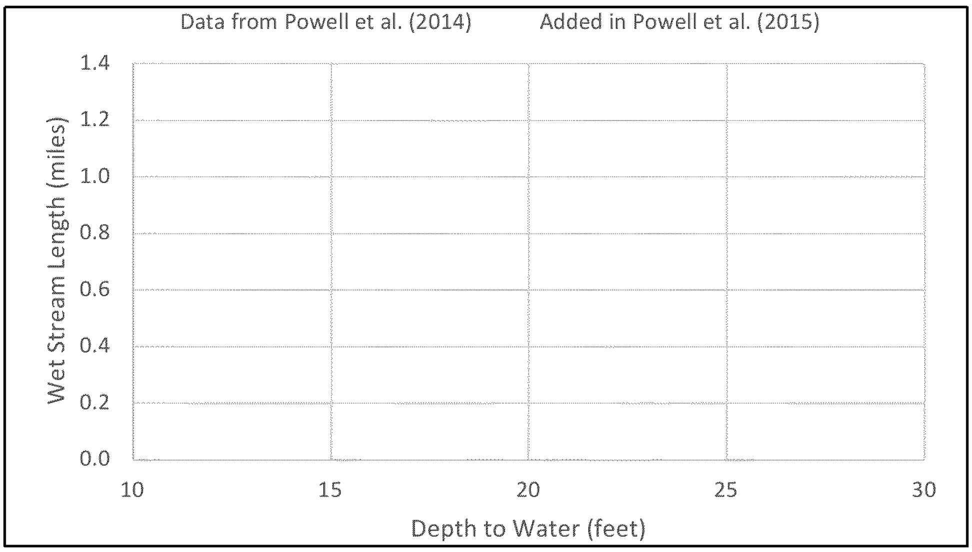

Figure 8. Davidson Canyon *flow length* versus *depth to water* at well Davidson #2. Data from Figure 5 of Powell et al. (2014).

The sample data were modeled using simple linear regression instead of a model that accounts for censored data. This means that any predictions, such as the 30 percent reduction in *flow length* due to a 0.98-foot increase in depth to water (Powell et al. 2014), are invalid.

[1] Powell et al. (2015) states that three points were added since Powell et al. (2014), but only two new points can be seen in Figure 6 of Powell et al. (2015).

4.2. POWELL ET AL. (2014) AND POWELL ET AL. (2015) FAIL TO NOTE OR UNDERSTAND THE EFFECT OF SEASON ON THE REGRESSION.

All of the samples relating *depth to water* and *flow length* in Davidson Canyon, in both Powell et al. (2014) and Powell et al. (2015), were taken in March, June, September, or December. In this discussion, *month* represents the month the *flow length* and *depth to water* measurements were taken, but it also represents the season before the measurements.

At this time, we have the *month* and *year* related to 25 of the 26 samples shown in Figure 5 of Powell et al. (2014), or 25 of the 28 or 29[2] sample points used in Powell et al. (2015). **Table 5** shows the results of four simple and multivariate linear regressions completed by us. As discussed above, the models that include *flow length* as the response variable are not valid because *flow length* is a censored response variable; however, we will only use them for comparison with the Powell et al. (2014) and Powell et al. (2015) regression models.

Table 5. Results of simple and multivariate regressions using 25 points found in Figure 5 of Powell et al. (2015).

Response Variable	Explanatory Variables	Coefficient of Determination (R^2)	P-Value	Notes
flow length	*depth to water*	0.80	<0.0001	Same model as Powell et al. (2014) with one less data point. Powell et al. (2014) R^2 = 0.77
flow length	*month*	0.72	<0.0001	*month* is March, June, September, or December
flow length	*month & depth to water*	0.85	<0.0001	*month* is March, June, September, or December
depth to water	*month*	0.69	<0.0001	

In the first row, the coefficient of determination (R^2) implies that *depth to water* explains 80 percent of the variation in *flow length*. This matches closely with the results in Powell et al. (2014). The second row shows the results of a simple linear regression of *flow length* on *month*. The regression implies that *month* explains 72 percent of the variation in *flow length*. The third row shows the results of a multivariate linear regression of flow length regressed on both *month* and *depth to water*. The multivariate regression implies that 85 percent of the variation in *flow length* is explained by the combination of *depth to water* and *month*.

Because *depth to water* alone (R^2 = 0.80) and *month* alone (R^2 = 0.72) each explain almost all the variation demonstrated by the multivariate model that uses both *month* and *depth to water* (R^2 = 0.85), *month* and *depth to water* must be related.

[2] Ibid.

The fourth row in **Table 1** shows the results for regressing *depth to water* on *month*. *Month* explains 69 percent of the variation in *depth to water*. *Flow length* and *depth to water* cannot result in the month of June or September; it is more likely that both *flow length* and *depth to water* are affected by something related to *month* or *seasonal changes*, such as precipitation. The relationship between *flow length* and *depth to water* noted in Powell et al. (2014) and Powell et al. (2015) is due to both variables responding to seasonal changes. Indeed, the language used to describe the relationship between *flow length* and *depth to water* has evolved from an implication of causation in Powell et al. (2014) to a correlative or "concomitant" relationship in Powell et al. (2015), so there appears to be at least some recognition of this more likely conclusion.

The simplistic analyses in Powell et al. (2014) and Powell et al. (2015) do not demonstrate an impact of the Rosemont Project on flow length or depth to water. The analyses do demonstrate correlations between several natural processes that have occurred and will continue to occur in the future.

4.3. Other Statistical Problems in Powell et al. (2015)

In addition to the issues described in **Sections 4.1** and **4.2**, the following is a list of items that likewise make it difficult to interpret and assess Powell et al. (2015).

1) Powell et al. (2015) indicate three new data points have been added to the data in Powell et al. (2014), but Figure 6 of Powell et al. (2015) only shows two.
2) The *y*-axis in Figure 6 of Powell et al. (2015) is missing numerical values. If not for our familiarity with the data from Powell et al. (2014), we would not have been able to analyze these data.
3) The *y*-axis and *y*-axis title are missing numerical values in Figure 7 of Powell et al. (2015).
4) For the multivariate regression, Powell et al. (2015) reports an □statistic as □$_{9,29}$, meaning 9 and 29 degrees of freedom, which is incorrect based on the information provided. The first subscript represents □−□1, where □is the number of parameters, and the second subscript represents □−□□, where □□is the sample size. The variable □$_{9,29}$ implies 10 parameters and a sample size of 39. The sample size is 28 (26 from Powell et al. [2014] and 2 additional points). The number of parameters in the multivariate analysis is eight: a constant, *depth to water*, *year* (as a continuous variable), three for *month* (1 less than the number of months), and three for the *month/year* interaction. The correct nomenclature for the F statistic should have been $F_{7,20}$.
5) Referring to the multivariate model, Powell et al. (2015) did not state how much of the variation is explained by *depth to water* but instead reports, "Of course, the relationship to depth to water explained most of the variation." It is in no way obvious that *depth to water* explains most of the variation in *flow length*, given that *month* explains nearly as much of the variation (which Powell et al. [2015] also failed to report) (see **Table 5**).

6) The multivariate analysis should not have included *year* and the *year/month* interaction as explanatory variables because these are not statistically significant in any combination.

4.4. Summary of Depth to Water/Flow Length Relationship Critique

Powell et al. (2015) is plagued with statistics issues both in using appropriate models and in interpreting model results. Two major issues call into question the results of their analysis of *flow length* versus *depth to water*. First, Powell et al. (2015) inappropriately use linear regression on data with a censored (limited) response variable. Second, the *month* the sample was taken explains almost as much of the variation in *flow length* as *depth to water*, and Powell et al. (2015) does not address the likely circumstance that *depth to water* and *flow length* are not both reacting to seasonal changes.

5. CONCLUSION

In an effort to demonstrate their assertion that the impacts of the proposed Rosemont Copper Project have been understated, Powell et al. (2015) conclude that: 1) Barrel Canyon provides a disproportional amount of surface water within the Davidson Canyon watershed, 2) the shallow groundwater aquifer in Davidson Canyon is highly responsive to pulses of surface water flow, and 3) there is a strong statistical relationship between depth to water and length of streamflow in Davidson Canyon. However, the analysis by Powell et al. (2015) includes errors in analysis and interpretation that undermine these conclusions. The comparison of surface water runoff in Barrel Canyon to that in lower Davidson Canyon is based on a flawed application of the surface water gauge data in both systems, and the dataset is so limited that it renders the analysis nearly meaningless. The relationship between stormwater runoff and the recharge of the shallow alluvial aquifer is well understood by the permitting agencies, and the "demonstration" by Powell et al. (2015) neither refutes nor adds to the agency disclosures and determinations. Finally, the statistical analysis is based on substantial flaws in both the methodology used and the interpretation of results, resulting in inappropriate conclusions about the relationship between depth to water and length of streamflow.

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Seeing the Water for the Models: Pima County's Modeling of Rosemont Mine Impacts on Water Resources in Davidson Canyon Remains Robust Despite Comments by Westland Resources et al. (2016)

May 24, 2016

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> "The EIS must identify all the indirect effects that are known, and make a good faith effort to explain the effects that are not known but are 'reasonably foreseeable'." *(Council on Environmental Quality 1981)*

Introduction

As the federal decision-making process around the proposed Rosemont Mine comes to a close, Pima County and Pima County Regional Flood Control District continue to gather data relating to the stewardship of lands downstream of the proposed mine and to understand potential impacts of the mine on key resources on these same downstream lands. The two principal areas of concern are the Cienega Creek Natural Preserve and the Bar V Ranch (Figure 1), which were purchased with public funds with the explicit purpose of preserving the ecosystem integrity of these landscapes. Linking the two areas is Davidson Canyon, which contains both riparian and aquatic habitats.

In 2015, Pima County provided the U. S. Environmental Protection Agency (EPA) and others a report (Powell et al. 2015) that contained additional information relevant to the inadequacies of the federal conclusions regarding the effects of the mine upon Davidson Canyon, particularly the riparian systems within and downstream of it. This was the latest in a series of County reports and memos (e.g., Pima County 2013; Huckelberry 2014; Powell et al. 2014; Canfield 2016) addressing various long-standing inadequacies in the Final Environmental Impact Statement (FEIS; U.S. Forest Service 2013), the federal mitigation measures regarding surface water and groundwater conditions, and the potential effects of the mine.

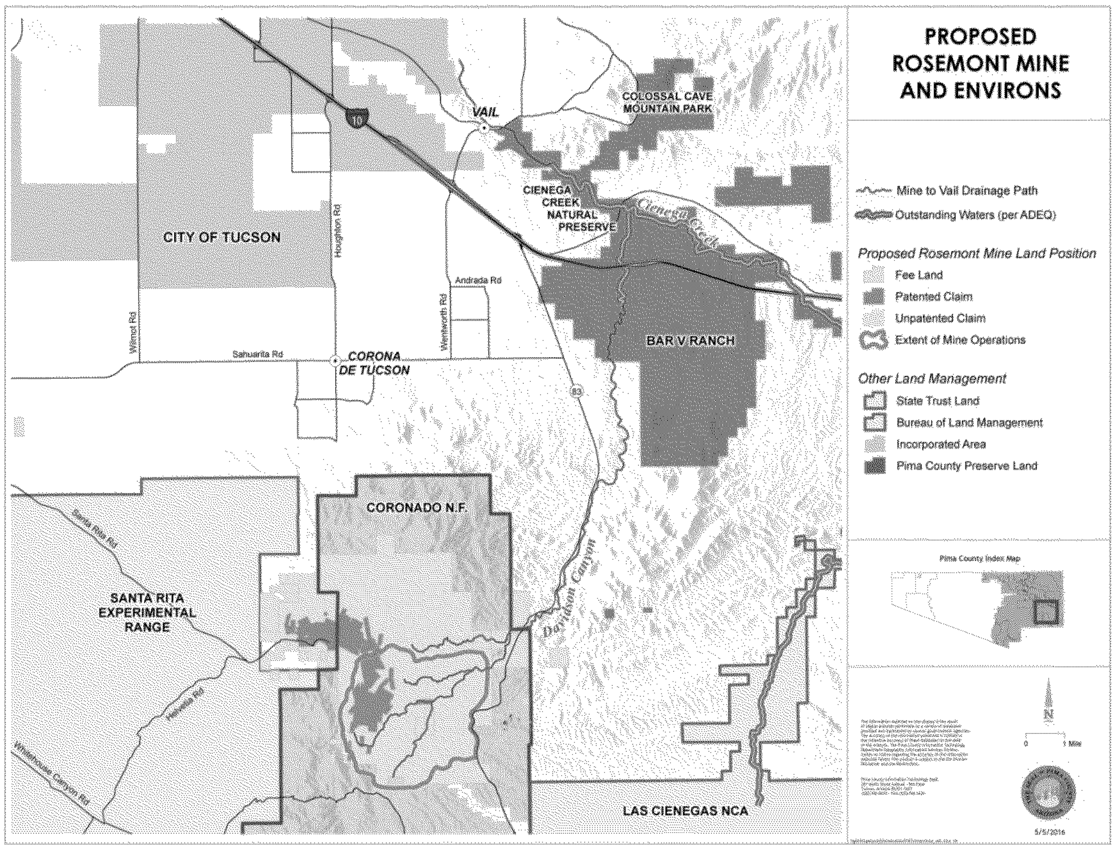

Figure 1. Location of the proposed Rosemont mine in relationship to Davidson Canyon, Cienega Creek, and key conservation lands.

Deficiencies of the FEIS and the proposed mitigations for waters regulated by the U.S. Army Corps of Engineers (Corps) have long concerned the EPA as well as other federal agencies involved in the Rosemont project. As a result, the Council on Environmental Quality (CEQ) has been periodically convening the federal agencies to discuss their differences, in hopes of resolving issues before the Corps and U.S. Forest Service issue their decisions.

Key uncertainties remain regarding the impacts of the mine, and Pima County has brought forward a robust dataset on key water resources in Davidson Canyon such as depth to shallow groundwater resources, stormwater flows, and length of surface water baseflows. At the request of the EPA, Pima County gathered together these data and presented the results (Powell et al. 2015).

Just prior to the CEQ's most recent field visit (April 2016), federal agencies involved in the Rosemont issue received comments prepared for Rosemont Copper Company[1] (WestLand et al. 2016) that sought to refute many of the key points addressed by Powell et al. (2015). The

[1] The report submitted to Rosemont had little in the way of referenced or assigned authorship, so barring additional information; it is referred to here as Westland et al. (2016).

purpose of this Pima County report is to respond to the criticisms outlined by Westland et al. (2016); our responses generally follow organization of that report.

2. Contribution of Barrel Canyon to Davidson Canyon

Westland et al. (2016) points out the difficulties of quantifying the distribution of runoff in Barrel and Davidson Canyons while adding nothing to the knowledge base of these watersheds. Pima County continues to maintain that the hydrologic analysis in the FEIS is deficient in identifying the stormwater impacts to Davidson Canyon and Cienega Creek, and Powell et al. (2014, 2015) have used the most complete available data and scientifically sound methodologies to advance our general understanding of these systems.

Westland et al. (2016) fail to present a scientifically supported alternative understanding of these systems, but instead simply point out perceived flaws and limitations found in the Powell et al. (2015) analysis. They identify limitations in using gage records from the Pima County Automated Local Evaluation in Real-Time (ALERT) system to conduct hydrological analyses. Westland et al. (2016) also discuss the lack of a comprehensive understanding of the spatial and temporal variability in rainfall across the local landscape, as well as the difficulty in using both USGS and ALERT gages to quantify streamflow volumes, but fail to present any robust alternative explanation to model the hydrological dynamics of these systems.

While we acknowledge there is much we do not currently understand, the onus is on Rosemont to demonstrate that their project will not adversely impact these resources. For example, Pima County has repeatedly suggested using the Soil Water Assessment Tool (SWAT) to evaluate the effects of the Rosemont mine on flows in Davidson Canyon. We understand that there is currently a modeling effort underway to help reduce some uncertainty around this issue, and we sincerely hope that that effort will be employing and adapting the recently published SWAT model (Niraula et al. 2015).

The following model parameterization suggestion has been made to the Arizona Department of Environmental Quality and HudBay previously (Canfield 2016), but we repeat it here:

1.) **Limits** – watershed of Davidson Canyon through the confluence with Cienega Creek.
2.) **Topography** –
    a. Existing Conditions - PAG LiDAR data at 10' resolution Grid.
    b. Maximum Diversion – Rosemont Mine Plan of Operations (modification of existing conditions topography at mine site only)
    c. Post Closure – Rosemont Mine Plan
3.) **Curve Number** – use PC Hydro tables (available on Web PCHydro, which are based on SSURGO soils data (10m) and reclassified Southwest ReGAP cover). Evaluation vs observed data runoff data (Stewart et al 2013) has indicated that the PC Hydro Curve Number values show less systematic bias than the USDA CN Tables.
4.) **Vegetated Cover -**
5.) **Observed Climate –** period of record coincident with observed runoff monitoring at Barrel Canyon (USGS 09484580 2009 to present)

6.) **Historical Climatic Data** - PRISM climatic data (800m) input
    a. 30 yr 'Normal' climate with the SWAT Weather Generator
    b. Daily Precipitation
    c. High and Low Temperature
    d. Reference ET
7.) **Simulations**
    a. Baseline (pre-site development)
    b. Maximum Diversion
    c. Post-closure
8.) **Evaluation Point**
    a. At Mine Compliance Point
    b. Upstream Edge of OAW
    c. At Confluence of Davidson Canyon and Cienega Creek

Evaluation Criteria

1.) **Model Comparison with Observed at Barrel Canyon Gage**
    a. Number of Days of flow
    b. Peak Daily Flow and Volume
    c. Seasonal volume of flow
    d. Annual volume of flow
2.) **Historical Climate Modeling of Annual Volume -** for Each 30 year simulation
    a. High Volume
    b. Low Volume
    c. Average
3.) **Historical Climate Modeling of Seasonal Volume -** for Each 30 year simulation
    a. High Volume
    b. Low Volume
    c. Average

Influence of Barrel Canyon and the Orographic Effect

If constructed, the Rosemont Mine would impact water inputs (e.g., stormwater and baseflow) to Davidson Canyon. An important element to understanding the extent and duration of those impacts is a more comprehensive description of the role that water movement through Barrel Canyon contributes to the hydrology of downstream regions in Davidson Canyon and Cienega Creek. Furthermore, a physical process known as the orographic effect must be considered to fully understand the dynamics of water movement through watersheds moving across significant topographical relief.

The orographic effect, which is the phenomenon of higher precipitation at greater elevation due in part to the reduced capacity for an air mass to retain moisture as the temperature decreases beyond its dew point, is a well-documented and accepted phenomenon (e.g., Daly et al. 1994) and is used in a wide variety of modeling approaches. Westland et al. (2016) incorrectly echoes Rosemont's continued assertions (citing the FEIS) that orographic effects have been accounted for in their assessment of mine impacts to the watershed.

The FEIS very clearly *does not include orographic effects* because the equation used to determine this did not contain an orographic effect parameter in the modeling of the predicted reductions in storm flow, making any estimates of the mine's impacts incomplete. Page 536 of the FEIS concludes the following:

> *Changes in surface flow and, therefore, to the recharge to shallow alluvid aquifers are possible as a result of disturbance by the mine and the removal of portions of the watershed upstream. The effect of the reduction in surface flow is estimated and could reduce storm flows by* ***<u>4.3 [for the Preferred Alternative] to 11.5 percent,</u>*** *depending on alternative, but this effect on recharge is likely to be overestimated, with the contribution being less owing to the distance downstream of the project area and substantial channel losses. Predictions of loss of recharge to the shallow alluvial aquifer have a high level of uncertainty because of the nature of the channels and the relatively great distance between the impacts from the proposed mine and lower Davidson Canyon. (USFS 2013)*

However, the values of 4.3 percent to 11.5 percent come from a numerical calculation (cited as SWCA Environmental Consultants 2012) that in turn cited Zeller (2011), which uses the calculation:

$$\square_{\square\square} = ?\frac{\square_{\square\square}}{\square_{\square\square}}?^{0.6636} \qquad \square_{\square\square}\ \square\ \square\ \square\ \square$$

Where:

> Q_{AAr} is the reduced average annual runoff (acre-ft)
> Q_{AAn} is the average annual runoff under natural conditions (acre-ft)
> A_r is the reduced watershed area assuming some diversion to mine (square miles)
> A_n is the natural watershed area (square miles)

Importantly, because there is no parameter that models precipitation included in this equation, the equation clearly does not take into consideration any orographic effects, or differences in annual rainfall at higher elevations in the watershed. In fact, Zeller 2011 states: "<u>assuming on a watershed-wide basis the average-annual precipitation, P, would not change meaningfully</u> as a consequence of a small reduction in watershed size". Consequently, because the language in the FEIS clearly cites these calculations, it is clear that the modeled impacts did not take into consideration average annual precipitation (p. 428-429).

As such, Pima County continues to assert that orographic effects are not accounted for in the assessment of downstream runoff volumes in the FEIS, that the inclusion of these effects in the modeling of post-mine conditions may significantly alter the current analysis of impacts in the FEIS, and that the continued assertion that they are accounted for is factually in error.

Data Limitations
In section 2.2 of their report, Westland et al. (2016) point out that precipitation is variable across the landscape, a phenomenon that is well known in particular for southern Arizona. Westland et al. (2016) go on to cite data from two precipitation gauges in the Cienega Creek watershed (including the Empire Peak gage, the highest elevation in the watershed) and use the differences between the precipitation data collected at these two locations to seemingly suggest that the orographic effect does not, in fact, exist.

Pima County is aware that the Empire Peak precipitation gage consistently shows lower readings than other, lower elevation gages in the watershed (Powell 2013); we have been transparent about this observation. Though we do not know for sure why this is the case, we suspect that it is because the gage is placed at the highest point on Empire Peak and that consequently wind impacts the estimate. This is a well-known phenomenon that has been widely accepted by the scientific community and that is taken into consideration when interpreting precipitation data collected in such a scenario (Nešpor and Sevruk 1999). The Regional Flood Control District placed the gage at Empire Peak because other infrastructure is located on that site and not because it is representative of precipitation at that elevation. If, in fact, the orographic effect does not exist in the Barrel and Empire areas, then surely meteorologists would be interested in this anomaly.

In Section 2.1 of the April 19 Memo, Westland et al. (2016) attacks the use of ALERT streamflow data used in the Powell et al. (2015) report, and then in section 2.2 uses ALERT precipitation data to support their assertions, thereby highlighting the inconsistencies in their criticisms. The fact is that in both cases the limited spatial and temporal data available underscores the need for additional instrumentation and monitoring to accurately characterize the surface water hydrology of Barrel and Davidson Canyon, something that is lacking in the FEIS. They observe that the relative lack of directly measured hydrologic data, temporally abbreviated datasets and the coarse spatial distributions of data-collecting instruments makes using these data difficult to adequately describe watershed characteristics. In fact, the flaws pointed out (some valid and some not) actually corroborate the County's position that the FEIS has not adequately described the proposed Rosemont Mine's impact on the Davidson Canyon watershed. If, as they point out, the available data is insufficient to characterize the watershed's hydrologic characters, how is it possible to, at the same time, use the very same data to reach the conclusion that these resources will not be adversely impacted? Of course the available datasets have limitations, and additional data and analyses are warranted and needed. We continue to maintain that Hudbay has a responsibility to add to the knowledge base considering their potential to significantly impact these resources, but seemingly they have resisted doing so thus far.

Westland et al. (2016) asserts that ALERT data in Davidson Canyon does not account for low flows.
One of the primary criticisms by Westland et al. (2016) is that discharge values of zero are assigned to flow depths less than 1.4 feet at the Davidson Gauge (ALERT site 4313). This issue is not that low flow data was not collected or that ALERT streamflow sensors are not capable of—

or suitable for—capturing low and moderate flows. In fact, the flow sensor at ALERT station 4313 is located directly at the channel invert and is in a position specifically designed to measure low and moderate flows as well as flood flows (Figures 2 and 3).

The ratings used to display data on the ALERT website http://alert.rfcd.pima.gov/perl/pima.pl are sometimes intentionally truncated for a variety of reasons, and the truncated data set was used in the Powell et. al (2015) report. The complete data set, with discharge estimates for all stage values (including those below 1.4 feet for the period of July 15 – November 25 2015), is included in Figure 4.

Assigning discharge values to low flows increases the total flow volume calculation for the period of July 15 – November 25 of 2015 from 470 acre-feet—as reported in Powell et al. (2015)—to approximately 1600 acre-feet. The 470 acre-feet figure suggested that a disproportionately large percentage of total Davidson Canyon watershed volume is produced by Barrel Canyon. While the higher estimates of surface flow seems to counter our original argument, it is, as pointed out by Westland et al. (2016) a very short data set and the distance between the USGS gage at Barrel Canyon makes quantifying the overall flow contribution from these watersheds a difficult exercise for both Pima County and Rosemont. Neither Pima County nor Westland's analyses can correct the fact that the FEIS has done an inadequate job at describing the proposed Rosemont mine's impact on stormwater and baseflows in Barrel and Davidson canyons.

Figure 2. ALERT site 4313. Picture shows the location of the re-located pressure transducer outside of the stilling well. Photo taken on September 29, 2015.

Figure 3. ALERT site 4313. View is upstream and shows the location of the pressure transducer located at the channel invert. Photo taken on September 29, 2015.

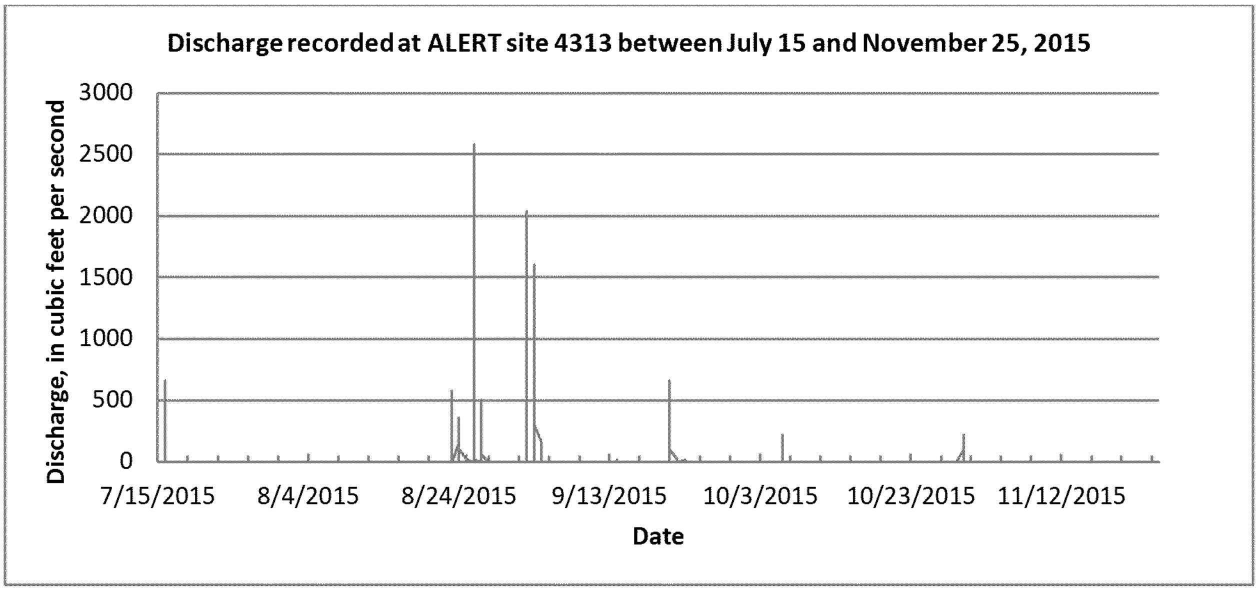

Figure 4. Non-truncated dataset of all storm water discharge, including flows of less than 1.4 feet, at ALERT site 4313 in Davidson Canyon for July 15 – November 25, 2015.

Additionally, Westland et al. (2016) also challenge the use of ALERT data recorded at ALERT site 4313 based on their presumption that scour and sedimentation have not been accounted for and that the stage/discharge relationship has not been maintained to account for changes in bed elevation. Westland et al. (2016) arrives at this conclusion erroneously. In fact, subtle shifts in the rating are made based on measured invert elevation after every field visit, which is typically twice per year. The mistake made by Westland et al. (2016) in this criticism is that the website they accessed (http://alert.rfcd.pima.gov/perl/pima.pl) is meant to display real-time data and not to disseminate historic information. The website disclaimer clearly states that the data are for "general information only". The database software used by this website to convert stage (depth) to discharge only allows one rating for the entire period of record so shifts or adjustments in the rating cannot be ascertained by an examination of data derived from this source alone. Internally, our primary ALERT database is operated with more sophisticated base station software that allows multiple ratings and invert elevation adjustments to be applied to multiple discrete time periods.

Furthermore, in the interest of transparency, these data are now available to be used to help reduce any uncertainty about the impacts of the Rosemont Mine and we welcome the use of these data.

2.3 Runoff Variability

Westland et al. (2016) presents a discussion of runoff variability between the USGS gauge 09484580 located at Barrel Canyon and the ALERT site 4313 streamflow gauge. It is unclear what exactly they are trying to establish but they show that runoff occurred at both locations on the same day on only three occasions during the July 15 – November 25, 2015 sampling period. As noted above, Westland et al. (2016) used an incomplete record of discharge for their analysis. In actuality, when using the complete dataset (Figure 5), it is clear that 70-percent of runoff events measured at the Davidson Canyon ALERT gage occurred on days where discharge was also recorded at Barrel Canyon. Barrel Canyon recorded more days of runoff than Davidson Canyon, but 50-percent of the runoff events recorded at Barrel Canyon also corresponded with days where runoff was measured at Davidson Canyon. As we have already acknowledged and pointed out, this temporally narrow data set is not sufficient to fully describe long-term watershed characteristics, but it does suggest that runoff events in the upper and lower watershed are not as temporally isolated as Westland et al. (2016) claim.

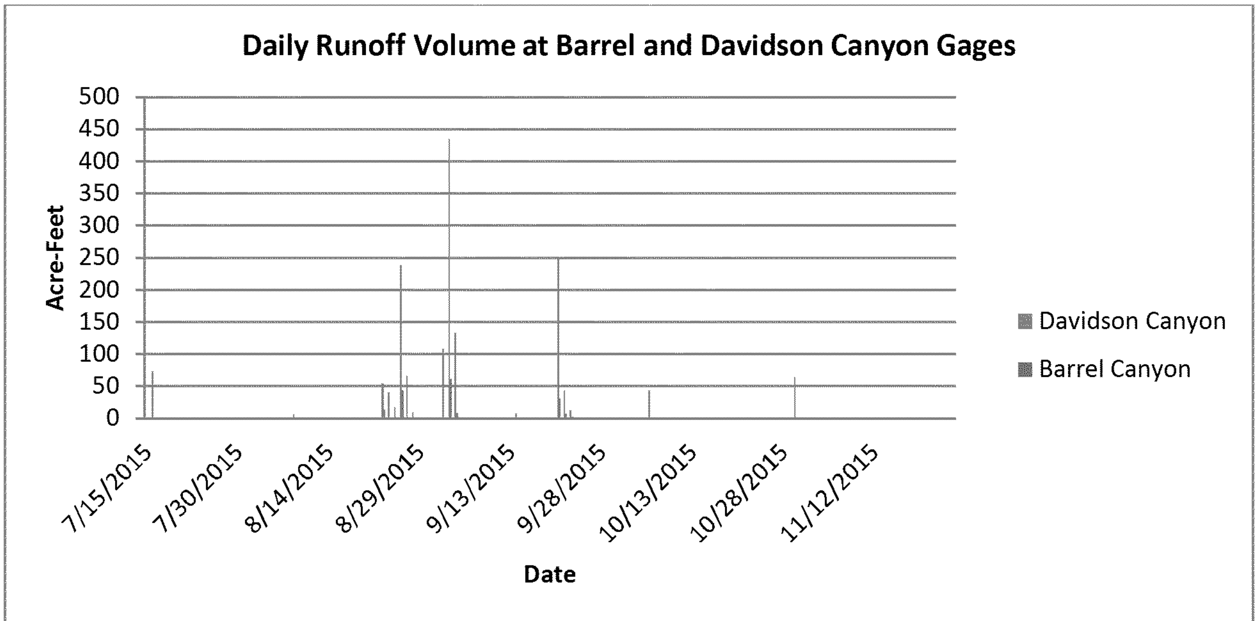

Figure 5. Runoff volume (acre feet) comparison between Davidson and Barrel canyon showing their close correlation.

3. Influence of Streamflow on aquifer recharge in Davidson Canyon

In section 3 of their report, Westland et al (2016) state that the correlation between stream flow and shallow groundwater levels is "axiomatic", well known to Arizona Department of Water Resources, and addressed in the Forest Service's Final Environmental Impact Statement (FEIS) for the Rosemont project. In fact, the FEIS does not adequately account for the fact that the project will starve Davidson Canyon of baseflow and stormflows, both of which are critical to both streamflow AND groundwater recharge. Pima County has long questioned the equation on which the widely cited loss of 4-11.5% of surface water contributions is predicated. In fact, that reported figure is based on work by Zeller (2011) and Krizek (2010) with follow-up work by SWCA Environmental Consultants (2012). None of these efforts looked at the baseflow conditions; Krizek (2010) for example, only looked at stormflows, and did not address baseflow, which means that these efforts present an incomplete scenario of the true complexity of the hydrologic system in the watershed.

By contrast, Pima County has brought forward a robust and long-term dataset on the relationship between flow, streamflow length, and depth to groundwater at lower Davidson Canyon. More recently, that dataset has been enhanced by an automatic datalogger in the Davidson 2 well, which allows for a greater insight into the responsiveness of the local aquifer to both stormflows and baseflows. These are critical and valid lines of evidence and can be used to model reductions in baseflow and stormflows to Davidson Canyon, similar to the work by Powell et al. (Figure 2; 2014). Unfortunately, Westland et al. (2016) did not take an opportunity to use the available Davidson Canyon data to model impacts on streamflow length, but instead simply criticized the model that Pima County used to do so.

4. Relationship between depth to water and length of streamflow in Davidson Canyon

Westland et al. (2016) was critical of the model produced by Powell et al. (2015) examining the relationship between streamflow length and depth to groundwater. Here we take a closer look at that critique, but it is important to note that here we will not address at length all of the minor quibbles perceived by Westland et al. (2016, section 4.3) with regards to "other statistical problems"; in a few cases they are correct (e.g., an axis was not labeled), but in most cases they are neither correct nor do their points refute the fundamental relationships that are so important to the issues at hand.

A primary concern to Westland et al. (2016) is that Powell et al. (2015) used a linear model with "censored response variables". We appreciate the authors pointing out this statistical minutiae to us and thus we have rerun the analysis without the zero values and with the two new values from late 2015. Figure 5 is the result of the re-run model using simple linear regression, which accounts for 71% of the variation in the data. Had Westland et al. (2016) done these analyses themselves, they would have seen that removing the zero values had no impact on the model outcome.

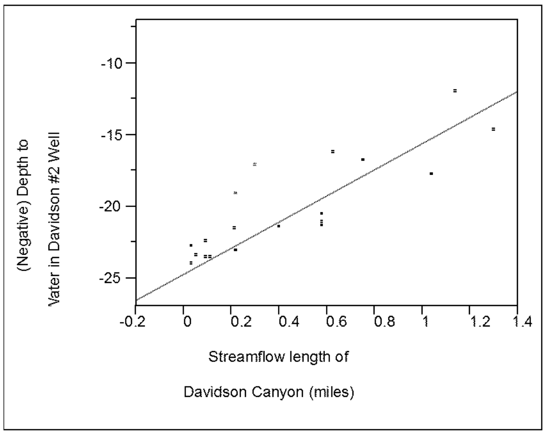

Figure 5. The relationship between streamflow length and depth to water in the Davidson #2 well. This is the same as Figure 6 in Powell et al. (2015) but with the zero values removed. Removing the zero values had no impact on the strong statistical relationship. The environmental connection between these two variables remained the same.

The second key issue raised by Westland et al. (2016) is that Powell et al. (2015) "fail to note or understand the effect of seasonal changes on the regression model." This is false from both the perspective of interpretation and modeling. From the modeling perspective, the variable *month* was used in the original analysis as an explanatory variable. As a response to the Westland et al. (2016) suggestion to exclude the zero values, we reran the analysis, which gave us 19 data points. The coefficient of determination (or the proportion of the variation in the dependent variable that is predictable from the independent variable) of the model that includes both month and depth to water is 0.73, which is similar to the coefficient of determination of the re-run model (0.71). Because an advantage of multiple linear regression is its ability to inform us of the relative contribution of each variable to the model, we weighed the contribution of month and depth to water. We find that depth to water has considerably greater influence on the model than does month. Westland et al. (2016) failed to note this fact and instead suggested that a series of simple linear regression analyses with high coefficients of variation was the same as saying they all contributed about the same to the model outcome. Their attempt at a multivariate regression failed to highlight the relative contributions of month and depth to water.

From the perspective of interpretation, Westland et al. (2016) state that month in the final model is really a proxy for precipitation. Precipitation, not month, is clearly the driver and we see the expression most dramatically as stormflow in Davidson Canyon, but its influence on baseflow conditions (measured as length of streamflow) and depth to water are also evident.

Conclusion

By trying to discredit Powell et al. (2015), Westland et al. (2016) appear to be attempting to create a diversion from the real issue. Scrub away minor statistical issues and concerns about labeling axes and we in fact find some level of common agreement: precipitation is driving stormflows and baseflows and thus aquifer recharge, aquatic resources, and mesic and hydroriparian wildlife and their habitat. Altering the key outcomes of precipitation, stormflow and baseflow, will impact these key resources.

Natural variation in these systems is well known and documented, including Powell et al. (2015), but the key question that Pima County and others have unsuccessfully lobbied the Forest Service to thoroughly address for years remains: what additional impact will the Rosemont project have on these resources? As noted elsewhere in this report, the work by Krizek (2010) is woefully inadequate. It is unfortunate that instead of using robust statistical and technical methodologies to contribute to a better understanding of these resources, the companies behind the Westland et al. (2016) report simply disparage legitimate attempts to do so. The famous statistician John Tukey once said: "far better an approximate answer to the right question, which is often vague, than an exact answer to the wrong question, which can always be made precise". We think that Westland et al. (2016) and other analyses by Rosemont consultants continue to seek precise answers to the wrong questions.

In conclusion, neither our analysis nor theirs can completely address the deficiencies of the EIS. Modeling of changes in the Davidson watershed was identified as a need, and the FEIS was completed without adequate analyses. We once again call on the Forest Service to uphold the letter and spirit and NEPA by using models that account for variation in rainfall in addition to modeling the projected land-use impacts to storm flows and baseflows and the resulting diminishment of hydrological and biological resources of Davidson Canyon and lower Cienega Creek.

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